KEY CONCEPT

2.3 Properties are used to identify substances.

BEFORE, you learned

- Matter can change from one state to another
- Changes in state require energy changes

NOW, you will learn

- How properties can help you identify substances
- How properties of substances can be used to separate substances

EXPLORE Identifying Substances

How can properties help you identify a substance?

MATERIALS

- substance A
- substance B
- 2 cups
- water

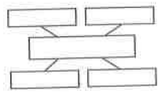
PROCEDURE

1. Place some of substance A into one cup and some of substance B into the other cup. Label the cups.
2. Carefully add some water to each cup. Observe and record what happens.

WHAT DO YOU THINK?

- Which result was a physical change? a chemical change? Explain.
- The substances are baking soda and baking powder. Baking powder and water produce carbon dioxide gas. Which substance is baking powder?

MAIN IDEA WEB
As you read, place each blue heading in a box. Add details around it to form a web.



Substances have characteristic properties.

You often use the properties of a substance to identify it. For example, when you reach into your pocket, you can tell the difference between a ticket stub and a folded piece of tissue because one is stiff and smooth and the other is soft. You can identify nickels, dimes, and quarters without looking at them by feeling their shapes and comparing their sizes. To tell the difference between a nickel and a subway token, however, you might have to use another property, such as color. Texture, shape, and color are physical properties that you use all the time to identify and sort objects.

CHECK YOUR READING How can physical properties be used to identify a substance?

Identifying Unknown Substances

Suppose you have a glass of an unknown liquid that you want to identify. It looks like milk, but you cannot be sure. How could you determine what it is? Of course, you would not taste an unknown substance, but there are many properties other than taste that you could use to identify the substance safely.

To proceed scientifically, you could measure several properties of the unknown liquid and compare them with the properties of known substances. You might observe and measure such properties as color, odor, texture, density, boiling point, and freezing point. A few of these properties might be enough to tell you that your white liquid is glue rather than milk.

To determine the difference among several colorless liquids, scientists would use additional tests. Their tests, however, would rely on the same idea of measuring and comparing the properties of an unknown with something that is already known.

Properties Used for Identifying Substances

You are already familiar with the most common physical properties of matter. Some of these properties, such as mass and volume, depend upon the specific object in question. You cannot use mass to tell one substance from another because two very different objects can have the same mass—a kilogram of feathers has the same mass as a kilogram of peanut butter, for example.

Other properties, such as density, can be used to identify substances. They do not vary from one sample of the same substance to another. For example, you could see a difference between a kilogram of liquid soap and a kilogram of honey by measuring their densities.

The physical properties described below can be used to identify a substance.

Aerogel, an extremely lightweight material used in the space program, has such a low density that it can float on soap bubbles.

Density The densities of wood, plastic, and steel are all different. Scientists already have determined the densities of many substances. As a result, you can conveniently compare the density of an unknown substance with the densities of known substances. Finding any matching densities will give you information about the possible identity of the unknown substance. However, it is possible for two different substances to have the same density. In that case, in order to identify the substance positively, you would need additional data.

CHECK YOUR READING Why can't you identify a substance on the basis of density alone?

These fibers act as heat insulators to keep the inside of the sleeping bag warm.

Heating Properties Substances respond to heating in different ways. Some warm up very quickly, and others take a long while to increase in temperature. This property is important in selecting materials for different uses. Aluminum and iron are good materials for making pots and pans because they conduct heat well. Various materials used in household insulation are poor heat conductors. Therefore, these insulators are used to keep warm air inside a home on a cold day. You can measure the rate at which a substance conducts heat and compare that rate with the heat conduction rates of other substances.

Solubility Solubility is a measure of how much of a substance dissolves in a given volume of a liquid. Sugar and dirt, for instance, have very different solubilities in water. If you put a spoonful of sugar into a cup of water and stir, the sugar dissolves in the water very rapidly. If you put a spoonful of dirt into water and stir, most of the dirt settles to the bottom as soon as you stop stirring.

READING TiP
The root of the word *solubility* is the Latin word *solvere*, which means "to loosen."

Electric Properties Some substances conduct electricity better than others. This means that they allow electric charge to move through them easily. Copper wire is used to carry electricity because it is a good conductor. Materials that do not conduct easily, such as rubber and plastics, are used to block the flow of charge. With the proper equipment, scientists can test the electric conductivity of an unknown substance.

Iron filings are attracted by the magnet. The wood chips, however, are not.

Magnetic Properties Some substances are attracted to magnets, but others are not. You can use a magnet to pick up a paper clip but not a plastic button or a wooden match. The elements iron, cobalt, and nickel are magnetic—meaning they respond to magnets—but copper, aluminum, and zinc are not. Steel, which contains iron, is also magnetic.

Mixtures can be separated by using the properties of the substances in them.

Suppose you have a bag of cans that you want to recycle. The recycling center accepts only aluminum cans. You know that some of your cans contain steel. You would probably find it difficult to tell aluminum cans from steel ones just by looking at them. How could you separate the cans? Aluminum and steel may look similar, but they have different magnetic properties. You could use a magnet to test each can. If the magnet sticks to the can, the can contains steel. Recycling centers often use magnets to separate aluminum cans from steel cans.

Some mixtures contain solids mixed with liquids. A filter can be used to separate the solid from the liquid. One example of this is a tea bag. The paper filter allows the liquid water to mix with the tea, because water molecules are small enough to pass through the filter. The large pieces of tea, however, cannot pass through the filter and remain inside the tea bag.

INVESTIGATE Separating Mixtures

How can a mixture of sand, salt, and pepper be separated?

DESIGN YOUR OWN EXPERIMENT

Scientists often have to isolate a single substance from a mixture. Use your knowledge of the properties of sand, salt, and pepper to design a method for separating each of these substances from the mixture.

SKILL FOCUS
Designing experiments

MATERIALS
- mixture of sand, salt, and pepper
- 2 index cards
- comb
- felt
- graduated cylinder
- spoon
- water
- coffee filter
- funnel
- small cup
- pie tin

TIME
30 minutes

PROCEDURE

1. Examine the mixture and the materials provided. Design a procedure for separating the different substances in your mixture. Carefully consider the order in which you will try each step.
2. Write up your procedure. Explain why you chose the steps you did for each substance.
3. Carry out your procedure.

WHAT DO YOU THINK?

- Was your procedure successful? How would you modify your procedure if you were to perform the separation again?
- How does knowing the properties of matter help you separate the substances in mixtures?

This water-treatment plant separates harmful substances from the water.

Some mixtures are more difficult to separate than others. For example, if you stir sugar into water, the sugar dissolves and breaks up into individual molecules that are too tiny to filter out. In this case, you can take advantage of the fact that water is a liquid and will evaporate from an open dish. Sugar, however, does not evaporate. The mixture can be heated to speed the evaporation of the water, leaving the sugar behind.

There are many important reasons for separating substances. One reason is to make a substance safe to consume, such as drinking water. In order to produce drinking water, workers at a water-treatment plant must separate many of the substances that are mixed in with the water.

The process in water-treatment plants generally includes these steps:

- First, a chemical is added to the water that causes the larger particles to stick together. They settle to the bottom of the water, where they can be removed.
- Next, the water is run through a series of special molecular filters. Each filter removes smaller particles than the one before.
- Finally, another chemical, chlorine, is added to disinfect the water and make it safe to drink.

Water-treatment plants use the properties of the substances found in water to produce the clean water that flows from your tap.

CHECK YOUR READING What are two situations in which separating substances is useful?

2.3 Review

KEY CONCEPTS

1. How can properties help you distinguish one substance from another?
2. What are two physical properties that can help you identify a substance?
3. How can understanding properties help you separate substances from a mixture?

CRITICAL THINKING

4. **Apply** Why might an archaeologist digging in ancient ruins sift dirt through a screen?
5. **Synthesize** Suppose you had a mixture of iron pellets, pebbles, and small wood spheres, all of which were about the same size. How would you separate this mixture?

CHALLENGE

6. **Synthesize** You have two solid substances that look the same. What measurements would you take and which tests would you perform to determine whether they actually are the same?

CONNECTING SCIENCES

PHYSICAL SCIENCE AND EARTH SCIENCE

Workers can identify garnets in a mine because their physical properties are different from the physical properties of their surroundings.

Separating Minerals

A few minerals, such as rock salt, occur in large deposits that can be mined in a form that is ready to use. Most minerals, however, are combined with other materials, so they need to be separated from the mixtures of which they are a part. Scientists and miners use the differences in physical properties to analyze samples and to separate the materials removed from a mine.

Appearance

Gemstones are prized because of their obvious physical properties, such as color, shininess, and hardness. Particularly valuable minerals, such as diamonds and emeralds, are often located by digging underground and noting the differences between the gemstone and the surrounding dirt and rock.

Density

When gold deposits wash into a streambed, tiny particles of gold mix with the sand. It is hard to separate them by appearance because the pieces are so small. In the 1800s, as prospectors swirled this sand around in a pan, the lighter particles of sand washed away with the water. The denser gold particles collected in the bottom of the pan. Some modern gold mines use the same principle in machines that handle tons of material, washing away the lighter dirt and rock to leave bits of gold.

Magnetism

Machines called magnetic separators divide a mixture into magnetic and nonmagnetic materials. In order to separate iron from other materials, rocks are crushed and carried past a strong magnet. Particles that contain iron are drawn toward the magnet and fall into one bin, while the nonmagnetic materials fall into another bin.

Melting Point

Thousands of years ago, people discovered that when some minerals are placed in a very hot fire, metals—such as copper, tin, and zinc—can be separated from the rock around them. When the ores reach a certain temperature, the metal melts and can be collected as a liquid.

EXPLORE

1. **INFER** At a copper ore mine in Chile, one of the world's largest magnets is used to remove pieces of iron from the ore. What can you infer about the copper ore?
2. **CHALLENGE** Electrostatic precipitators are important tools for protecting the environment from pollution. Use the Internet to learn how they are used in power plants and other factories that burn fuels.

RESOURCE CENTER CLASSZONE.COM Find out more about separating materials from mixtures.

2 Chapter Review

the BIG idea

Matter has properties that can be changed by physical and chemical processes.

CONTENT REVIEW
CLASSZONE.COM

KEY CONCEPTS SUMMARY

2.1 Matter has observable properties.

- Physical properties can be observed without changing the substance.
- Physical changes can change some physical properties but do not change the substance.
- Chemical properties describe how substances form new substances.
- Chemical changes create new substances.

VOCABULARY
physical property p. 41
density p. 43
physical change p. 44
chemical property p. 46
chemical change p. 46

2.2 Changes of states are physical changes.

Matter is commonly found in three states: solid, liquid, and gas.

VOCABULARY
melting p. 51
melting point p. 51
freezing p. 52
freezing point p. 52
evaporation p. 53
sublimation p. 53
boiling p. 54
boiling point p. 54
condensation p. 55

2.3 Properties are used to identify substances.

Physical properties that can be used to identify substances include:

- density
- heating properties
- solubility
- electric properties
- magnetic properties

Mixtures can be separated by using the properties of the substances they contain.

Reviewing Vocabulary

Describe how the terms in the following sets of terms are related.

1. physical property, physical change
2. chemical property, chemical change
3. density, matter
4. melting, melting point, freezing point
5. boiling, boiling point, liquid
6. evaporation, condensation
7. sublimation, solid

Reviewing Key Concepts

Multiple Choice *Choose the letter of the best answer.*

8. Color, shape, size, and texture are
   - **a.** physical properties
   - **b.** chemical properties
   - **c.** physical changes
   - **d.** chemical changes
9. Density describes the relationship between a substance's
   - **a.** matter and mass
   - **b.** mass and volume
   - **c.** volume and area
   - **d.** temperature and mass
10. Dissolving sugar in water is an example of a
    - **a.** physical change
    - **b.** chemical change
    - **c.** change in state
    - **d.** pressure change
11. An electric current can be used to decompose, or break down, water into oxygen gas and hydrogen gas. This is an example of a
    - **a.** physical change
    - **b.** chemical change
    - **c.** change in state
    - **d.** pressure change
12. The formation of rust on iron is a chemical change because
    - **a.** the color and shape have changed
    - **b.** the mass and volume have changed
    - **c.** the substance remains the same
    - **d.** a new substance has been formed
13. The process by which a solid becomes a liquid is called
    - **a.** boiling
    - **b.** freezing
    - **c.** melting
    - **d.** evaporating
14. The process by which a liquid becomes a solid is called
    - **a.** boiling
    - **b.** freezing
    - **c.** melting
    - **d.** evaporating
15. Two processes by which a liquid can become a gas are
    - **a.** evaporation and boiling
    - **b.** melting and freezing
    - **c.** sublimation and condensation
    - **d.** evaporation and condensation

Short Answer *Answer each of the following questions in a sentence or two.*

16. When a sculptor shapes marble to make a statue, is this a physical or a chemical change? Explain your answer.
17. Describe and identify various physical changes that water can undergo.
18. Why does dew often form on grass on a cool morning, even if there has been no rain?
19. Describe the difference between evaporation and boiling in terms of the movement of the liquid's particles in each case.
20. What effect does altitude have on the boiling point of water?

Thinking Critically

21. **ANALYZE** Whole milk is a mixture. When bacteria in the milk digest part of the mixture, changes occur. Lactic acid is produced, and the milk tastes sour. Explain why this process is a chemical change.

22. **INFER** Sharpening a pencil leaves behind pencil shavings. Why is sharpening a pencil a physical change instead of a chemical change?

23. **ANALYZE** Dumping cooked spaghetti and water into a colander separates the two substances because the liquid water can run through the holes in the colander but the solid spaghetti cannot. Explain how this is an example of separating a mixture based on the physical properties of its components.

24. **INFER** The density of water is 1.0 g/mL. Anything with a density less than 1.0 g/mL will float in water. The density of a fresh egg is about 1.2 g/mL. The density of a spoiled egg is about 0.9 g/mL. If you place an egg in water and it floats, what does that tell you about the egg?

Use the photograph below to answer the next three questions.

25. **COMPARE** Which physical properties of the puddle change as the water evaporates? Which physical properties remain the same?

26. **ANALYZE** Can water evaporate from this puddle on a cold day? Explain your answer.

27. **PREDICT** What would happen to any minerals and salts in the water if the water completely evaporated?

Use the chart below to answer the next two questions.

Densities Measured at 20°C

Material	Density (g/cm^3)
gold	19.3
lead	11.3
silver	10.5
copper	9.0
iron	7.9

28. **PREDICT** Suppose you measure the mass and the volume of a shiny metal object and find that its density is 10.5 g/mL. Could you make a reasonable guess as to what material the object is made of? What factor or factors might affect your guess?

29. **CALCULATE** A solid nickel bar has a mass of 2.75 kg and a volume of 308.71 cm^3. Between which two materials would nickel fall on the chart?

the BIG idea

30. **PREDICT** Look again at the photograph on pages 38–39. The chef has melted sugar to make a sculpture. Describe how the sugar has changed in terms of its physical and chemical properties. Predict what will happen to the sculpture over time.

31. **RESEARCH** Think of a question you have about the properties of matter that is still unanswered. For example, there may be a specific type of matter about which you are curious. What information do you need in order to answer your question? How might you find the information?

UNIT PROJECTS

Check your schedule for your unit project. How are you doing? Be sure that you have placed data or notes from your research in your project folder.

Standardized Test Practice

Analyzing Experiments

Read the following description of an experiment together with the chart. Then answer the questions that follow.

Archimedes was a Greek mathematician and scientist who lived in the third century B.C. He figured out that any object placed in a liquid displaced a volume of that liquid equal to its own volume. He used this knowledge to solve a problem.

The king of Syracuse had been given a crown of gold. But he was not sure whether the crown was pure gold. Archimedes solved the king's problem by testing the crown's density.

He immersed the crown in water and measured the volume of water it displaced. Archimedes compared the amount of water displaced by the crown with the amount of water displaced by a bar of pure gold with the same mass. The comparison told him whether the crown was all gold or a mixture of gold and another element.

Element	Density (g/cm^3)
copper	8.96
gold	19.30
iron	7.86
lead	11.34
silver	10.50
tin	7.31

1. Which problem was Archimedes trying to solve?
- **a.** what the density of gold was
- **b.** what the crown was made of
- **c.** what the mass of the crown was
- **d.** how much water the crown displaced

2. Archimedes used the method that he did because a crown has an irregular shape and the volume of such an object cannot be measured in any other way. Which one of the following objects would also require this method?
- **a.** a square wooden box
- **b.** a cylindrical tin can
- **c.** a small bronze statue
- **d.** a rectangular piece of glass

3. Suppose Archimedes found that the crown had a mass of 772 grams and displaced 40 milliliters of water. Using the formula $D = m/V$, what would you determine the crown to be made of?
- **a.** pure gold
- **b.** half gold and half another element
- **c.** some other element with gold plating
- **d.** cannot be determined from the data

4. Using the formula, compare how much water a gold crown would displace if it had a mass of 579 grams.
- **a.** 10 mL
- **b.** 20 mL
- **c.** 30 mL
- **d.** 193 mL

5. If you had crowns made of each element in the chart that were the same mass, which would displace more water than a gold crown of that mass?
- **a.** all
- **b.** lead only
- **c.** tin only
- **d.** none

Extended Response

Answer the two questions below in detail.

6. What is the difference between a physical change and a chemical change? Include examples of each type in your explanation.

7. Why does someone cooking spaghetti at a high elevation need to boil it longer than someone cooking spaghetti at a lower elevation?